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PRECISION STELLAR CATALOGS AND THE ROLE OF ANOMALOUS REFRACTION--ETC(U)
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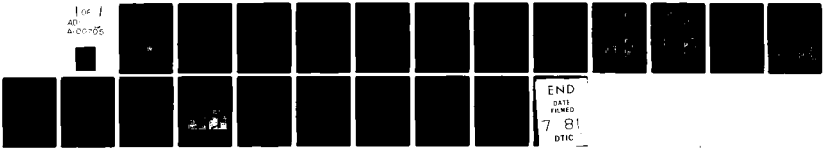

SEMIANNUAL REPORT NO. 1

ONR CONTRACT NO. N000-14-77-C-0541

TITLE: "PRECISION STELLAR CATALOGS AND THE ROLE OF ANOMALOUS REFRACTION"

Period Covered: June - December, 1977

by

Douglas G. Currie
Principal Investigator

January, 1978



UNIVERSITY OF MARYLAND
DEPARTMENT OF PHYSICS AND ASTRONOMY
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Technical Monitor: Dr. Fred Quelle
Alternate: Dr. Logan Hargrove

Jan[redacted]1978

## ABSTRACT

The current status of the University of Maryland program to evaluate the use of Two Color Refractometry (TCR) for the determination of precise stellar positions is discussed. Various aspects of the components of the program are considered in detail. The fabrication and operational progress with the hardware components is reviewed. A series of critical preliminary tests with TCR equipment operated on the 48-inch telescope have been conducted. The schedule for the various items of equipment which have been purchased and those which are being fabricated in-house is proceeding well. The technical and schedule aspects of several possible problem areas are discussed. A modification of the budget, which will have no cost or schedule impact, is being submitted separately to the Office of Naval Research to alleviate some of the above problems.

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# I. INTRODUCTION

In order to properly discuss the University of Maryland program to develop, fabricate and demonstrate the Two Color Refractometer with the objective of improving stellar catalogs, we first discuss the relation between the programs of the Office of Naval Research and the program of the Air Force Geophysical Laboratory. Although the final objectives and evaluation and measurement procedures of the two programs are quite different, a number of the hardware questions are similar. The AFGL system will be operated at a fixed focus of a large telescope, so many of the equipment problems are significantly less complicated than the problems for the ONR system, which must operate at all orientations, with less temperature control, and with higher F/number beams. However, the two units are sufficiently similar that a great deal which affects the ONR system will be learned during the fabrication and initial operation of the AFGL unit. Therefore the ONR schedule has be arranged so that most of the fabrication is being phased in a matter to permit this input to occur. At the present time, much of the preparation and definition of the ONR Two-Color Refractometer is closely related to the progress on the AFGL unit. Thus in this report, we shall include a detailed discussion of the status of the first unit (the AFGL unit). The AFGL unit will first be tested and used on the 48-inch telescope at GORF. Using what is learned from this use, we shall complete the components of the ONR system which are still open, since the ONR system has much tighter requirements due to projected use on various telescopes.

## II. REDEFINITION OF CAPITAL EQUIPMENT AND PERSONNEL BUDGET

Since an interval of four months elapsed between the submission of the budget contained in the proposal and the approval of the funds, certain aspects of the program costs changed. The most significant of these is a change in delivery dates and an increase in the cost of the Quadrant Photosil manufactured by the Electronic Vision Company. Due to this increase in cost and several other cost increases of much lesser magnitude, a redefinition of the budget to achieve the project must be considered. These projected budget modifications have been achieved with no change in the technical objectives or the overall schedule. There has however been a change in the expected capital equipment purchases and the salary distribution for the first year.

The reformulation of the capital equipment has a second purpose, i.e. to permit a proper description of each physically (rather than logically) distinct unit. The purpose of this reformulation in terms of physically distinct units is to permit a proper categorization within the University system for inventories. This is to assure that the item of capital equipment purchased or fabricated for the Office of Naval Research effort does not receive an inappropriate overhead charge.

To accomplish the cost reduction discussed above, the purchase or fabrication of several items (as indicated in the modified budget which is being separately submitted to ONR) is being delayed until the start of the second unit of funding, which is expected in June 1978.

## III. CURRENT STATUS OF EQUIPMENT ITEM

We now review the current status of the main hardware aspects of the program.

### A. External Purchases

In the case of most of the items of capital equipment which are being purchased from outside vendors, the bids have been requested, vendors selected, and orders placed. This includes the items which have particularly difficult delivery schedules, i.e. data processing equipment which must receive close scrutiny from both the State of Maryland and the Agency prior to initiating a long delivery schedule. Thus these orders include:

| Item | Vendor | Bid Requested | Approval Requ. | Approval Rec.* | Order Placed | Expected Delivery or Delivery Date |
|---|---|---|---|---|---|---|
| Data Processing System | Data General | 4/19/77 | 5/10/77 | 9/27/77 | 9/28/77 | 1/3/78 |
| Data Recording System | Data General | 4/19/77 | 5/10/77 | 9/27/77 | | |
| | Digidata | 4/19/77 | 5/10/77 | 9/27/77 | 9/28/77 | 2/1/78 |
| Image Stabilizer Motor | General Scanning Corp. | - | - | - | 10/26/77 | 11/8/77 |

* Approval to order received from Agency and the State of Maryland.

### B. Equipment Fabrication at the University of Maryland

#### 1. Display Control Console

Most of the electronic subsystems which are required to perform the various functions for the Two Color Refractometry are contained in the unit designated the "Display Control Console" (DCC) and the power supply for the Display Control Console. The functional design of this unit was completed prior to the award of the ONR contract. This design was refined

and fabrication was initiated on 7 September 1977 under work order #9023. At this time all of the integrated circuit cards have been designed and fabricated. Some of the cards which have been completed are the motor driver card, the universal counter cards, the digital multiplexor system card, and the guider control card. Photographs of these printed circuit cards are shown respectively in Figures 1 through 4. The various power supplies and some control subsystems for DCC (which is denoted as the Two Color Refractometer Power Supply) have been completed and are shown in Figure 5. A side view of the Display Control Console is shown in Figure 6.

The Display Control Console was received on its expected delivery date of 23 December 1977 from the Electronics Shop of the Department of Physics and Astronomy. Initial laboratory tests have already been completed. Several changes were made, and it is now operating in a quite satisfactory fashion and being subjected to further laboratory and telescope tests. The internal gain and offset bias parameters on a number of the servo-loops for a number of the various subsystems are now being measured and adjusted. Figure 9 shows the completed Display Control Console and its power supply mounted in its rack. We are here using a quadrant counter available from another contract to provide a dual monitor.

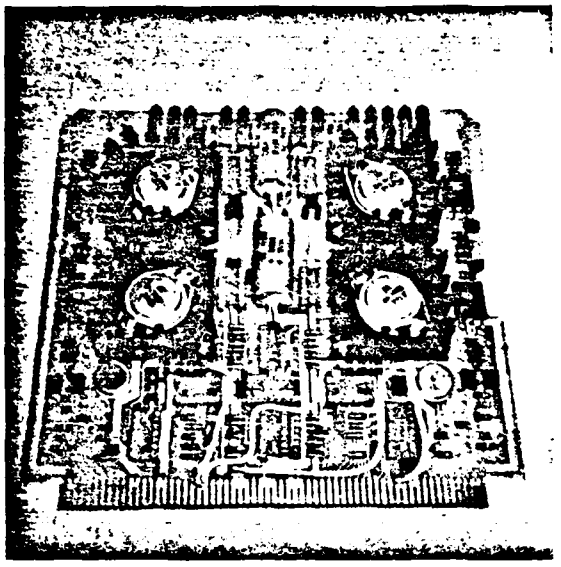


Fig. 1. Printed circuit board to operate the image stabilizer motors.

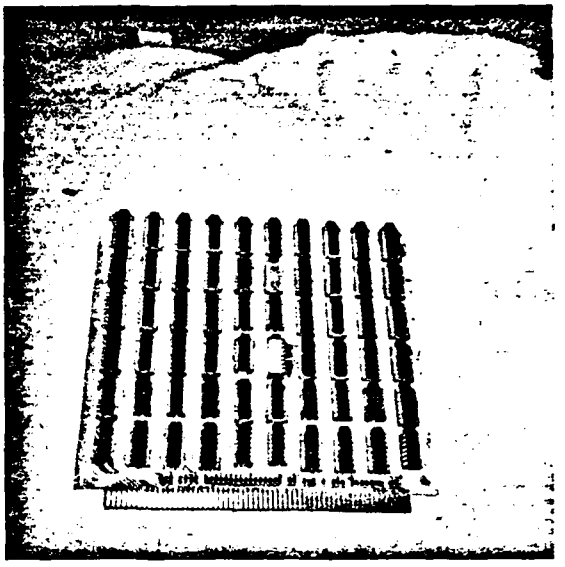


Fig. 2. "Universal Counter Module" which contains four separate digital counters in a generally addressable form.

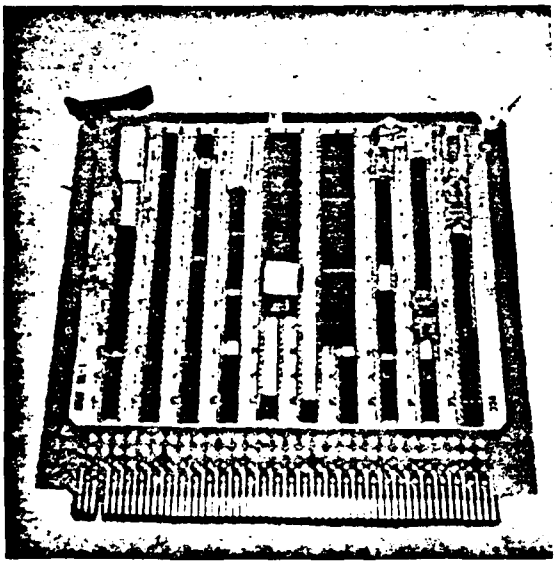


Fig. 3. The Digital Multiplexor System permits the serial, expandable communciation between the Display Control Console and the NOVA mini-computer.

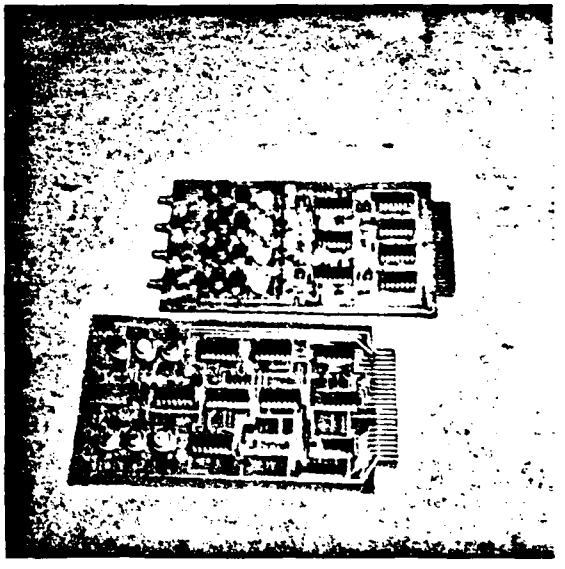


Fig. 4. Circuit board for the specialized Automatic Guider System electronics.

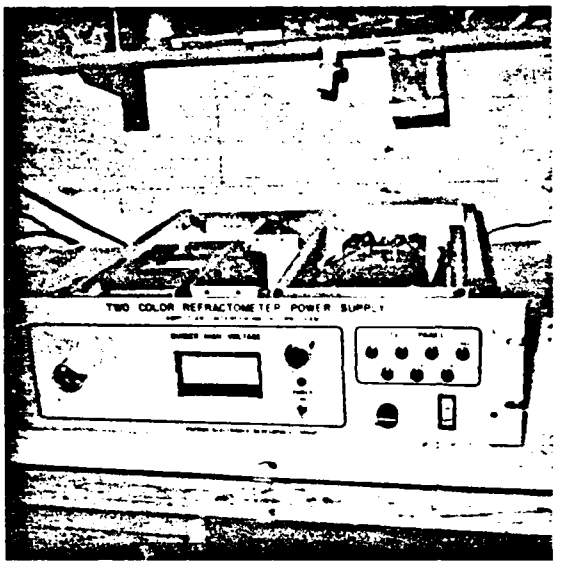



Fig. 5. Completed Two-Color Refractometer power supply for operating the Display Control Console.

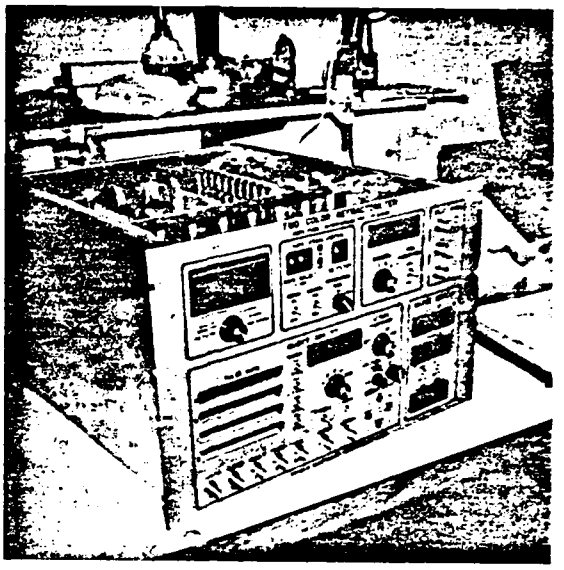


Fig. 6. Display Control Console in partially completed state.

Fig. 7. Preamplifiers for Quadrant Photosil in Automatic Guider System.

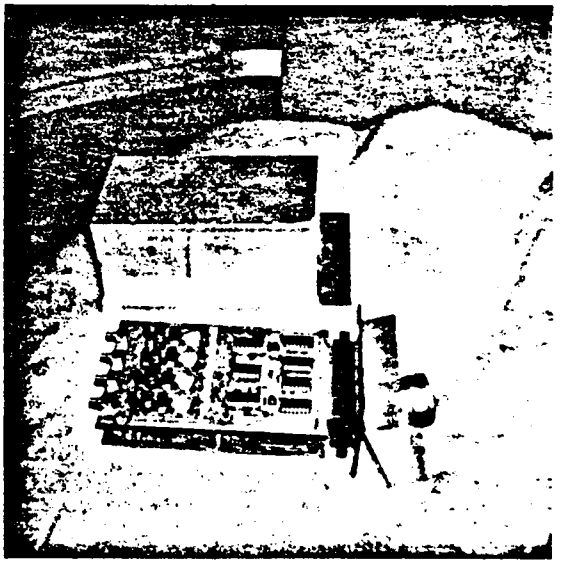


Fig. 8. Specialized electronics for Automatic Guider System.

2. Quadrant Sensor System

The camera head, the preamplifiers and the control unit of the Quadrant Sensor System have been completed. Final testing of these units is currently underway. A photograph of the camera head with the preamplifier is shown in Figure 7. The control unit for the guider system is shown in Figure 8.

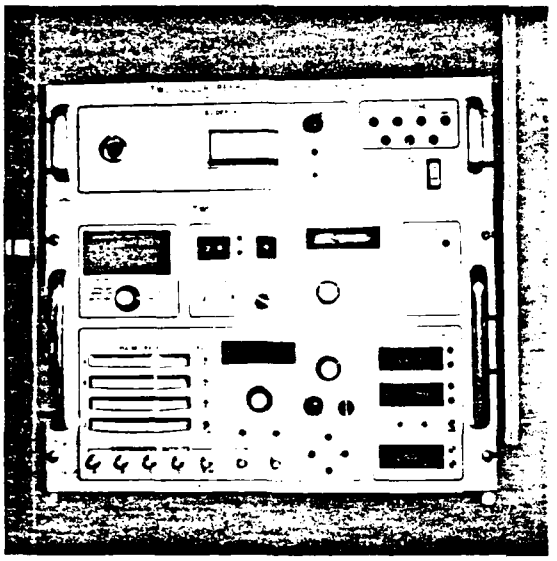


Fig. 9. The completed Display and Control Console with its associated power supply.

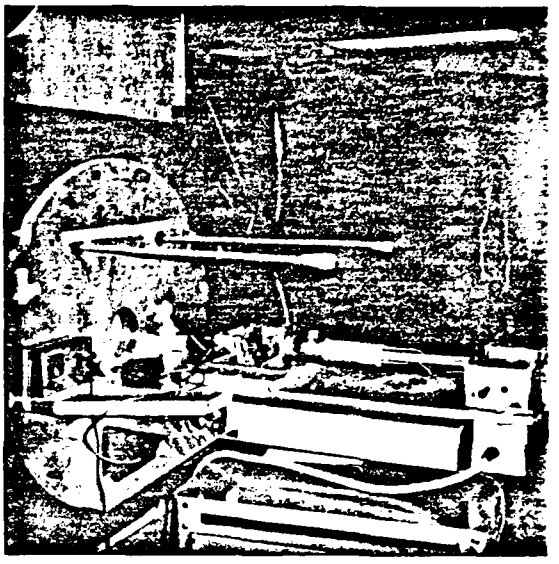


Fig.10. Automatic Guider System on borrowed Modified Multi-Mount mounted on the 48-inch telescope at GSFC.

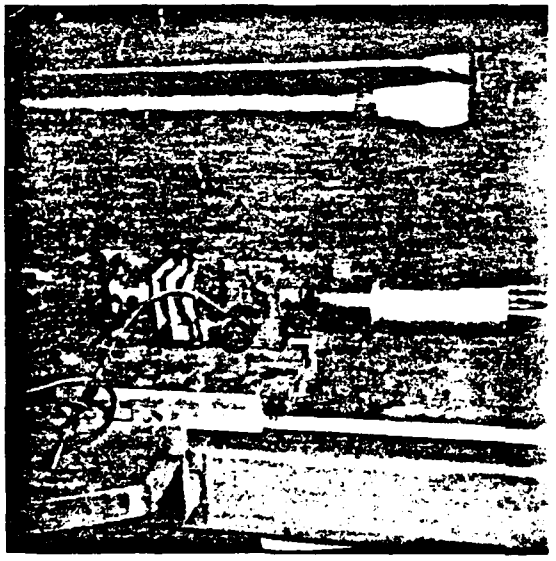


Fig.11. Closeup of Automatic Guider System camera head, eye piece, and miscellaneous optics.

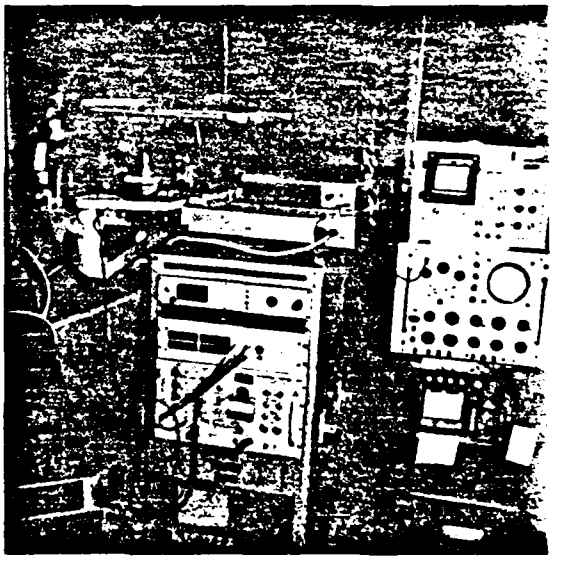


Fig.12. Electronics for running prototype Automatic Guider System at 48-inch telescope at Goddard Space Flight Center.

# IV. PROTOTYPE TWO-COLOR REFRACTOMETER SYSTEM

In order to expedite the development with the Two-Color Refractometer System, we are combining the University of Maryland/Goddard Space Flight Center effort with the development of the Two-Color Refractometry System. To this end, we are performing Two-Color Refractometry evaluations on components similar to those to be used on the Two-Color Refractometer on an existing Automatic Guider System which is being installed on the 48-inch telescope at the Goddard Optical Research Facility (GORF). Thus we are able to obtain data and evaluations relevant to Two-Color Refractometry on units which are available several months earlier than the actual units to be used in the TCR program. The tests which have been performed up to this time have consisted of tests upon the following units:

## A. Automatic Guider System

This subsystem has been operating for over one year. It has been properly interfaced to the Honeywell 716 which drives the telescope. Its performance and stellar sensitivity have approximately the level predicted by theory. However, some problems relating to a servo instability are now being addressed. Photographs of this system as it is currently installed at the GORF 48-inch telescope is shown in Figures 10 and 11.

## B. Neutral Density (ND) Filter Wheel

The Neutral Density Filter Wheel Assembly has been designed, fabricated and installed. The servo loop by which the position of the neutral density filter wheel is adjusted in order to keep the count rate uniform has been fabricated, tested and installed. This overall subsystem has been tested on the telescope and found to operate properly.

The mechanical unit comprising the ND filter wheel, motor, mount and position sensor appears in Figure 11 and the servo-control electronics unit appears in Figure 11 (the bottom unit in the rack). Detailed testing of this system indicated several modifications which permitted significant improvements in the unit fabricated for the field operation of the Two Color Refractometer. The primary change in the mode of operation was a change from a "limit" control to a proportional control. These modifications are installed in the servo loop control for the neutral density filter wheel which is incorporated in the Display and Control Console. This has been found to operate satisfactorily.

C. Stellar Magnitude Meter

The stellar magnitude meter is a subsystem to the neutral density filter wheel. It gives a direct readout indicating the stellar magnitude of the object being observed. This subsystem has been designed, fabricated, and installed, and is the top unit in the rack in Figure 12 This has been operating in a satisfactory manner. A similar unit has been included as part of the Display and Control Console.

D. Interface to the 48-inch Telescope

1. The electronic interface between the Automatic Guider System and the Honeywell 716 computer which operated the 48-inch telescope has been designed, fabricated, installed and tested. This has been operating properly and continues to perform as expected.

2. The software programs to drive the telescope in response to the Automatic Guider System inputs have been written and implemented. Preliminary tests of this indicate that it performs in a generally proper fashion. However there are servo instabilities which are being explored at this time. This work will continue in order to permit the use of the 48-inch telescope as the prime observing instrument.

# V. COMPUTER SYSTEM

The computer equipment has been received from the vendor. This has been interfaced and works as a integral system. Program development has started.

The interface to the DCC via the Digital Multiplexor System (DMS) has been tested using equipment from another project. This system which was operated is shown as the "top" unit in Figure 13. In Figure 14, we see the data control and processing system which is being used to conduct the current tests of the interfacing and to test the DMS.

Fig. 13. The computer system and the devices used to test the operation of the Digital Multiplexor System (DMS).

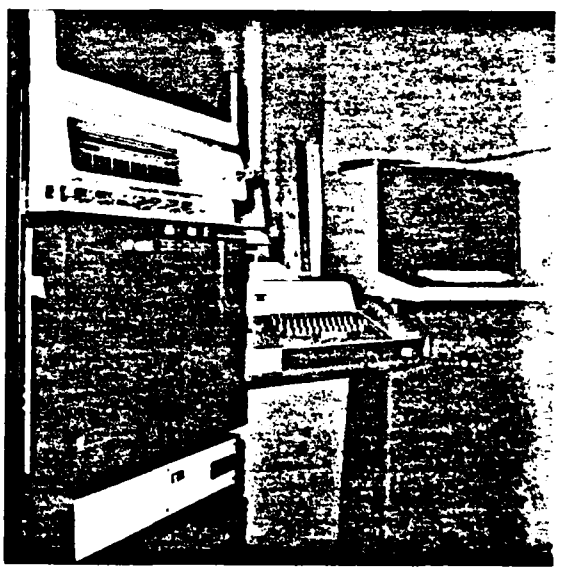


Fig. 14. The computer system, comprising the NOVA 3/12 computer, a 9-track tape transport and interface, & the Lexiscope CRT terminal.

# VI. SCHEDULE

A schedule for the significant events to be accomplished during this effort is discussed in this section.

Laboratory Subsystem Tests of the Two Color Refractometer (TCR)

All subsystems checked separately (except color wheel and dispersion wedges) with the Display & Control Console interfaced to the various subunits and with elements of the Data Control System electronically integrated separately. 24 February 1978

Initial subsystem tests on telescope at GORF

All subsystems (except color wheel and dispersion wedges) are to be interfaced to Display & Control Console and operated on the 48-inch telescope. The TCR system will be interfaced to the telescope. This time interval will include a major debugging of the overall system.

Start 15 March 1978

Completion 7 April 1978

Color Wheel and Dispersion Wedge

Final check out, installation and initial system operation of the color wheel and the dispersion wedges at the University of Maryland.

Start 17 April 1978

Completion 5 May 1978

Software Evaluation and Full System Operation

The full software system required for field operation will be installed and tested. We will make a continuous, long run at the University of Maryland over about three days.

Start 15 May 1978

Completion 31 May 1978

Finalize Critical Items for the Cassegrain TCR

Following the initial tests of the AFGL TCR on the stable mount on the 48-inch telescope, and the test of most of the components of the Cassegrain TCR (ONR) on using the Coude' TCR (AFGL) as a test bed, the critical items of the ONR system will be finalized for the projected use on the 24-inch telescope at the U.S. Naval Observatory. 22 May 1978

TCR Installation and Regular Observation Sequence

This will consist of the transfer of the TCR system to GORF and start regular data taking for the determination of refraction. The current projection of refraction observation at the rate of 3 nights per week.

Start 1 June 1978

Initial Tests of ONR TCR on the 36-inch telescope

Most of the subsystems of the Office of Naval Research Two Color Refractometry will be tested on the 36-inch. 21 June 1978

Test operation on 36-inch telescope

The Office of Naval Research TCR system will be installed and operated on the 36-inch telescope for a test. 3 July 1978

Preliminary dual observations

This will consist of simultaneous observations using one TCR on the 36-inch and one TCR on the 48-inch telescope. One of the TCR's will be used to measure the image motion and seeing and these will be correlated between the telescopes.

Start 17 July 1978

Completion 24 July 1978

Test and calibration of TCR at UM

This will consist of calibration of the ONR TCR in the laboratory at the UM using the reference source. 1 August 1978

Dual observing run

This consists of a regular data recording run with one TCR on the 48-inch and one TCR on the 36-inch.

| | |
|---|---|
| Start | 1 September 1978 |
| Completion | 15 September 1978 |

Long Term observing sequence

This consists of a regular long term observational run to collect data on low frequency (three day to monthly periods) refraction phenomena.

| | |
|---|---|
| Start | 1 October 1978 |
| Finish | 28 February 1979 |

USNO-PZT Test

This test consists of an observational sequence with the TCR operating on the 24-inch telescope physically near and simultaneous to the PZT. The TCR data will be used to correct the PZT measure. 1 January 1979

# VII. LIST OF SPECIFIC EQUIPMENT ACQUIRED OR DEVELOPED DURING THE PERIOD

On Order Equipment

| Supplier | Item Description | Purchase Order | Amount | Received |
|---|---|---|---|---|
| Electric Indicator Co. | 60Hz, 115V Motor, model No. 586 | Z-04728 | $ 170.30 | 12/22/77 |
| Digidata | NOVA Interface 9 Track Tape Transport | PO-W217634 | 5,100.00 | 2/1/78 |
| Data General | NOVA 3/12 System | PO-W217638 | 10,951.00 | 1/3/78 |
| Lexicon Inc. | Lexiscope, 2000 control boards and console-14"CRT | PO-W208178 | 2,367.50 | 10/20/77 |
| | | PURCHASE SUB-TOTAL: | $21,088.80 | |
| | | Constructed Equipment | | |
| UM Electronics Shop | Two Color Refractometer Electronics for Display Control Console | WO# 9023 | 12,395.25 | 12/23/77 |
| | TOTAL EQUIPMENT ORDERED, ACQUIRED OR DEVELOPED THROUGH 11-30-77 | | $33,484.05 | |

# VIII. ACADEMIC PERSONNEL

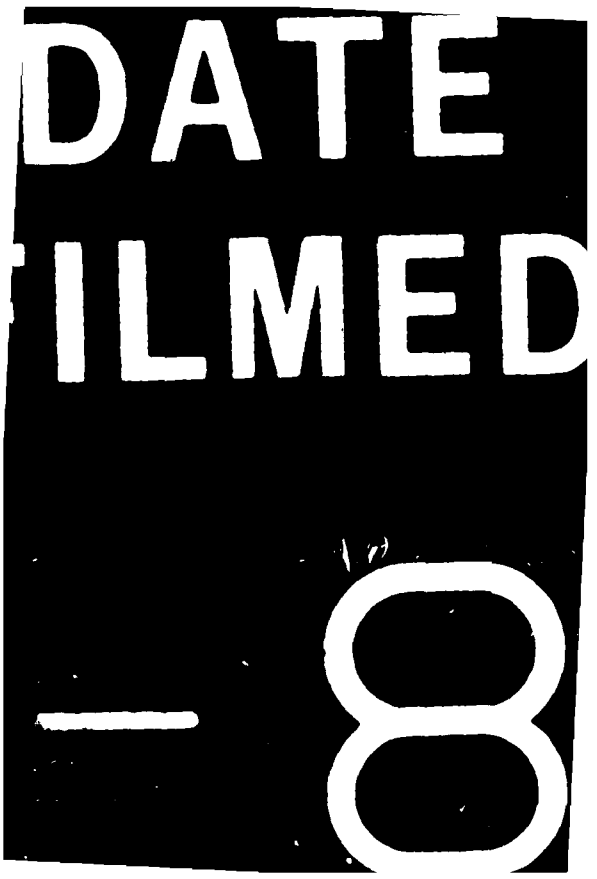
The academic personnel associated with this project consist of the following:

1. Dennis Wellnitz

   Mr. Wellnitz is a graduate sutdent in the Astronomy Program and is working with Two Color Refractometry as his Ph.D. thesis topic.

2. Kurt M. Liewer

   Dr. Liewer, a Research Associate who received his doctorate for research within our group, is working on various tasks related to the Two Color Refractometry effort. These tasks consist primarily of developing the Quadrant Photosil operation to its full requirement, developing the interface between the minicomputer and the electronics and some minicomputer programming which is required for instrument control.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